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Effects of Temperature and Aeration on The Dissolved Oxygen (DO) Values in Freshwater Using Simple Water Bath Reactor: A Brief Report

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Abstract

This work investigated the effect of temperature and aeration treatments on the dissolved oxygen (DO) values in freshwater. The study was carried out using a simple water bath reactor in room temperature condition. Based on the results, freshwater sample without the aeration and temperature treatments (control) indicates a fluctuating profile on which the obtained values of DO were 4.21-4.98 mg/L at $T_{average}$ = 27.7 °C. However, the aeration treatment was slightly able to enhance the DO value up to 8.12 mg/L from the initial concentration of 3.88 mg/L at $T_{average}$ = 27.4 °C. Compared to the aeration treatment, the addition of temperature treatment has extremely increased the DO value up to 21 mg/L from 6.6 mg/L ($T_{0\ minutes}$ = 27 °C) for 20 minutes of DO observation ($T_{20\ minutes}$ = 12.4 °C). Hence, this brief report suggests that the addition of temperature treatment gave a significant effect on the DO value in freshwater than the aeration treatment and control.

Keywords: Aeration; Dissolved Oxygen; freshwater; temperature.

Introduction

Water is one of the components that formed the earth's mantle Almost 70%, the earth is surrounded by water, and 15% in the vapour phase (Gabriel, 2001; Salmin, 2005). Water is very important for human life, agriculture, and industrial products (Terasaka et al., 2011). There is no doubt that all human activities need water such as for washing, cleaning, eat, and drink for daily usage.

During many years, the increasing use of water with the continued growth population, accelerated industrialization, urbanization and global climate change giving rise to environmental deterioration (Antanasijevic et al., 2020; Suthar et al., 2010). In addition, we are nowadays continuously facing the environmental problem including the water ecosystem. That might be caused naturally occur or human activities so that disturb the ecosystem equilibrium of nature, modification of the physical-chemistry of water, and hinders the external and internal relation of water ecosystem life. Further, the environmental pollution affects the water quality as well as the oxygen content in water (Panggabean and Prastowo, 2017).

The dissolved oxygen (DO) is one of the key parameters to assess the water quality as well as ecosystem health (Terry et al., 2017). Dissolved oxygen value means that an amount of gaseous oxygen (O_2) is

dissolved in an aqueous solution. Additionally, oxygen into water can be obtained by diffusion from the surrounding air, or aeration (rapid movement) and as a waste product of photosynthesis (Costa and Goncalves, 2011). A low-DO value from waters could be an indicator of a low performance of the oxidation process by microorganisms or bacterias (Komarawidjaja, 2003; Simanjuntak, 2007). However, it can be identified using water parameters such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) analysis (Alerts and Santika, 1984; Kristanto, 2002).

The existence of DO in water does not only depend on the presence of contaminants but it is depending on other parameters. They are mixing and turbulence of water mass, biological processes like photosynthesis activities, respiration, and remineralization of organic matter significantly affect the oxygen dissolution in water (Effendi, 2003; Rajwa-Kuligiewicz et al., 2015; Desmet et al., 2011).

Besides, the information about the factors which influence on oxygen dissolution especially in freshwater need more investigation such as their effect under the aeration and temperature addition. As far as reported information, the treatment of aeration and temperature addition to freshwater has not been studied before, hereby, it is necessary to be identified about this study. In this work, it will report briefly the effect of aeration and temperature addition on the relation between dissolved oxygen (DO) regarding temperature and aeration in freshwater using simple water bath reactor.

Materials and Methods

Materials sampling

Freshwater which was taken from drinking water CV Jaya Abadi Sejahtera (ATLAS) located at Desa Banteran Purwokerto Banyumas Central Java, and ice. The as-prepared freshwater was taken from the Slamet mountain stream which was assumed with the contaminants are negligible or in low-pollution concentration. The simple water bath reactor consisted DO meter (AZ 8403 type) combined with temperature recording for DO analysis, beaker glass 1 L, aerator using a commercial aquarium air pump (Luckiness 2W with a pressure of >0.02 MPa), and water bath (General Water Bath DAIKI Sciences Co. Ltd.),

A simple water bath reactor setting

Beaker glass with 1 L was placed into a water bath. Aerator hose was entered into beaker glass and was kept so that the oxygen stream from outside to the beaker glass system was stable in the bottom of beaker glass. Sensitive stick of DO meter (with temperature recording) was also placed into the bottom of beaker glass. The simple water bath reactor was displayed in Fig. 1 (a) and (b).

Determination of the aeration effect on the Dissolved Oxygen (DO)

Freshwater with 1000 mL was poured into beaker glass 1 L under room temperature. The DO meter and aerator were also introduced into beaker glass and then the DO meter was switched on. The measurement was left for few minutes until the stable DO meter was achieved. During the stable condition, the temperature at t = 0 was recorded and aerator was subsequently switched on. During the observation, DO value and time were recorded until a certain intervals time.

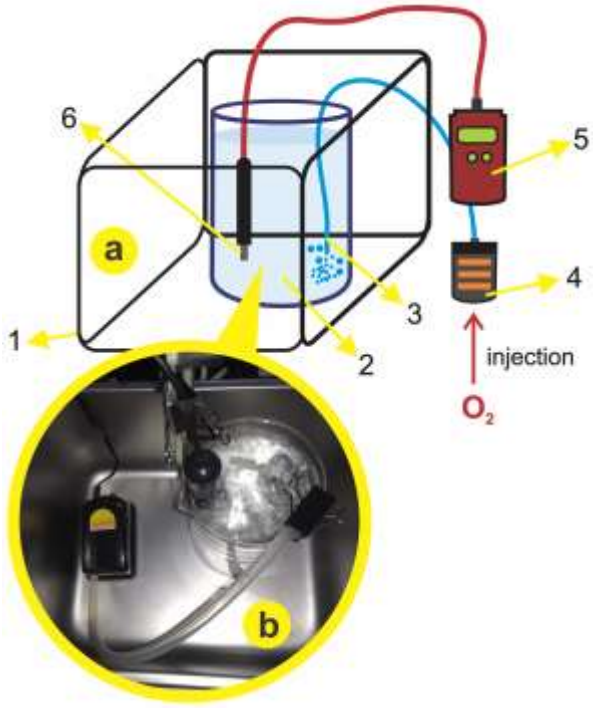

Figure 1. Full schematic illustration of simple water bath reactor (a) and real condition of the lab-experiment (b), respectively; composed by (1) reactor, (2) beaker glass 1 L, (3) aerator hose, (4) aerator, (5) DO meter, and (6) sensitive stick of DO meter.

Determination of temperature effect on the Dissolved Oxygen (DO)

Freshwater with 1000 mL was poured into beaker glass 1 L under room temperature. The DO meter was also introduced into beaker glass and then switched on. The measurement was left for minutes until the stable DO meter was achieved. During the stable condition, the temperature at t = 0 was recorded. Then, the ice was dropwise poured into a water bath. At this time, the DO content, time, and temperature were recorded until a certain intervals time.

Results and Discussion

Dissolved Oxygen (DO) control

Fig. 2 shows the freshwater sample without the addition of aeration and temperature treatments. As-resulted DO values of the freshwater sample without the treatment additions tend to vary during the observation time. It might be due to the transfer equilibrium of O_2 gaseous between oxygen content in water and air. At the t = 0 minutes, the observed DO was 4.81 mg/L at a temperature of 27.8 °C. The DO value decreased up to 4.21 mg/L when t = 70 minutes. The highest DO value was found at t = 20 minutes with 4.98 mg/L (27.8 °C). However, DO control was in the range of 4.21-4.98 mg/L with $T_{average}$ = 27.7 °C.

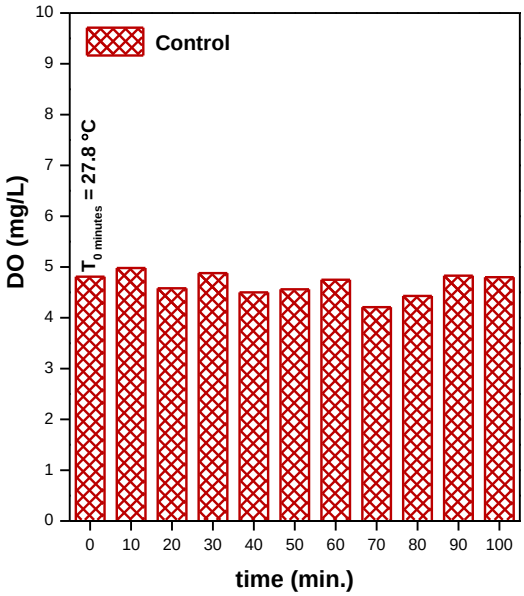

Figure 2. DO values of control.

Effect of aeration on Dissolved Oxygen (DO) value

Fig. 3 shows the DO value of freshwater during the addition of aeration treatment. The aeration gave a significant effect on the increase of oxygen dissolution. At the time of t = 0 minutes, the recorded DO value was 3.88 mg/L (27.7 °C), and shows the increase up to 106.44 % with 8.01 mg/L at t = 10 minutes (27.7 °C).

According to the Fig. 3, the aeration treatment of the freshwater sample can increase the oxygen dissolution. After 10 minutes, the DO value was slowly decreased even those do not significantly change the DO value up to the final aeration time of 100 minutes. This phenomenon intially was due to the oxygen content in the air is injected

using aerator from outside to water system so that oxygen content enhanced with the increase in DO recording. Moreover, the increase of DO value is proportional to the pressure of water flow (Lindeque and Woodley, 2020). Therefore, the addition of aeration treatment as oxygen feeding with a certain pressure could increase the values of DO than control well. Nonetheless, after 10 minutes of the aeration time, the values of DO was relatively constant. These might be caused by the system equilibrium between dissolved O_2 in water and the one released to the air (at room temperature) was taken place so that the resulted DO was the same during the long aeration treatment (t = 10-100 minutes).

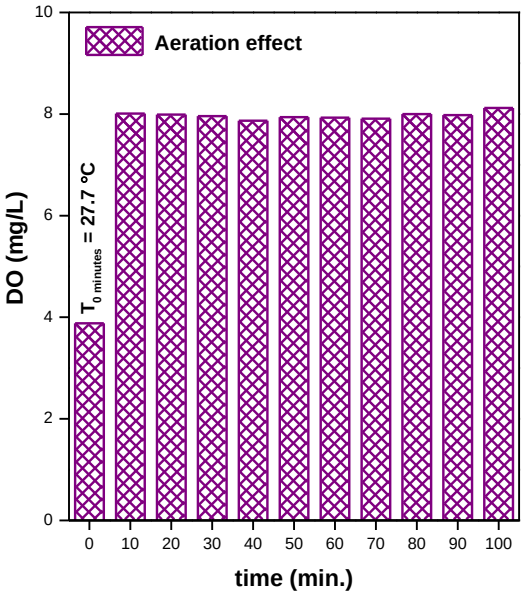

Figure 3. DO values of aeration effect.

Effect of the temperature on Dissolved Oxygen (DO) value

Fig. 4 and 5 indicate the obtained DO values and temperature that was conducted over the time of experiment for 100 minutes. The temperature treatment by decreasing the temperature system using ice showed a significant result to the increase of DO values in freshwater as shown in Fig. 4. Moreover, long experiment investigation was decreased the system temperature up to 3.7 °C from t = 80 to 100 minutes as displayed in Fig. 5. At t = 0 minutes, the identified DO value was approximately 6.6 mg/L (26.9 °C), it increased slowly, and enhanced to significant value up to 218.2% with DO of 21 mg/L at t = 20 minutes (12.4 °C). This condition remained constant even the decrease in temperature was taken place (up to the system temperature of 3.7 °C). The remained value of DO meter meaning that the maximum detection regarding the DO measurement, so the values are constant when the system temperature is decreased slowly.

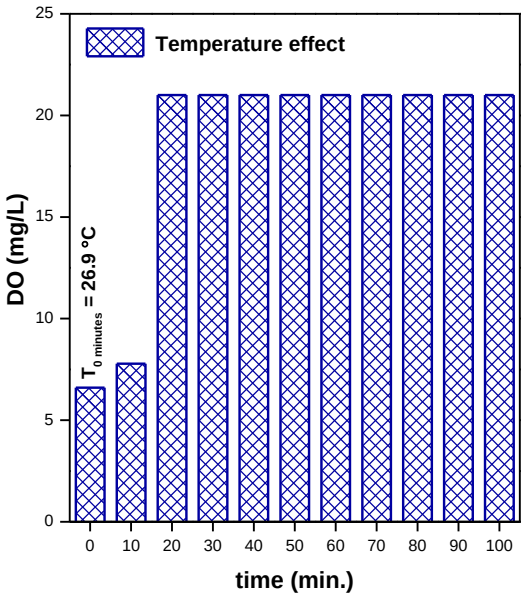

Figure 4. DO values of the temperature effect.

The effect of temperature treatment showed that the decrease of temperature in the system gradually, the DO values increased remarkably. This could be caused by the O_2 gases which are kinetically in lower energy. So that restricted their ability to transport from system to the air freely. A high temperature could decrease in DO content (Zammi et al., 2018). Conversely, in cold condition, it can hold more oxygen (Srebotnjak et al., 2012). However, the addition of aeration and temperature treatments are effective to enhance the DO values in freshwater compared to control as shown in Fig. 2. This research concluded that the DO value is effectively increased

following the order: temperature treatment >> aeration treatment > control.

Conclusion

Based on the results, the addition of aeration and temperature treatments indicated a significant effect on DO values in freshwater. Moreover, the decrease of temperature system showed a high result and effective way to enhance the DO value compared to the aeration treatment and control (without aeration and temperature treatments). In addition, the order of significant effect on DO values was presented as well: temperature treatment >> aeration treatment > control.

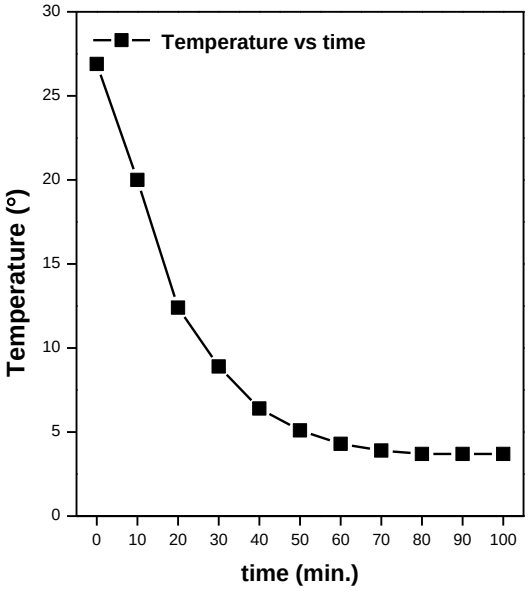

Figure 5. The effect of temperature treatment; temperature vs time.

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